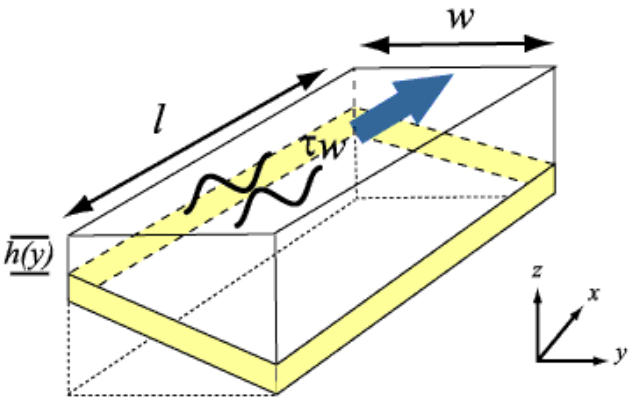
National Community Sediment-Transport Modeling Project

SUMMARY:

A community numerical modeling system to simulate erosion, transport, deposition, and fate of sediments in the coastal ocean is critically needed by scientists, engineers, and environmental managers dealing with coastal pollution problems, natural-resource management, impacts of navigation and resource-development projects, and hazard mitigation. Advancing our capability for predictive modeling in coastal regions is one of the three grand challenges identified by the National Research Council Ocean Studies Board (1999), and this need was recognized in the Geologic Division Unified Prospectus in FY2001, which called for improved understanding of the processes that transport sediment in coastal areas, and for prediction of coastal erosion and long-term health of coastal and marine environments. We need a modeling system developed and supported by a broad community of scientists, engineers, modelers, and decision makers. The ideal modeling system would implement peer-reviewed, process-based algorithms for circulation, sediment-transport, and biogeochemical processes related to pollution, eutrophication, and turbidity. The models included in the system should be well written in a modern programming language, well documented, well verified and tested, practical to modify or expand, and suitable for advanced computers. Models should also be open source and in the public domain and actively supported by an institution and an active user group. The community modeling system should also include model infrastructure, such as instructional resources for users, downloadable source code, pre- and post-processing tools, test cases, links to input and test data, and links to scientific results obtained with the models. Community modeling systems exist for comparable earth-science disciplines, such as meteorology, climate change, groundwater, and physical oceanography, and these tools have proved invaluable in advancing science and decision-making. At present, there is no community model available to scientists, engineers, or managers working in coastal and estuarine systems. The goal of this project is to promote and support the development of a such a modeling system.



Lake Signell model

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DESCRIPTION:

The ultimate objective of this project is to facilitate research into coastal sediment-transport processes and provide a mechanism to test and apply our understanding of those processes to important problems like coastal erosion and pollution. This project provides long-term core capabilities for modeling and fundamental process research in coastal circulation and sediment transport. The primary specific goal of this project is to build and maintain a state-of-the-art coastal sediment-transport model. The model is intended for use on USGS projects that require a process-based numerical model for quantifying transport of sediment, pollutants, and nutrients in estuarine and shelf environments, but it is also intended as a tool for other researchers and consultants who provide expert advice to coastal decision makers. A second important goal of this project is to advance the science and technology that underpins sediment-transport modeling. This includes building software tools to facilitate modeling, conducting field research to test models, and developing instruments and protocols that allow critical measurement of sediment-transport processes. Finally, a third goal of this project is to deploy and test the sediment-transport model on real-world applications to validate and improve the models and to provide advanced modeling results to project researchers.

START DATE OF PROJECT:

October 1, 2001

END DATE OF PROJECT:

September 30, 2006

TOPIC:

Coastal Erosion Assessements and Loss Reduction Products, Aquatic and Marine Processes Related to Human Health, Coastal, Wetland, Riverine, and Associated Watersheds, Offshore - Marine, Lacustrine, Resources and the Environment

APPROACH:

The strategy for accomplishing project objectives has changed slightly as the project has advanced. Our strategy has been influenced by the following events: a) OFA funding has been from ONR has encouraged work on EuroSTRATAFORM. Work in the Adriatic Sea has provided an ideal opportunity for testing the model against a very complete data set in a well-controlled environment. Funding for Gulf of Lions research has encouraged us to advance instrument development, which will ultimately improve our ability to evaluate the model. b) The needs of regional projects and the opportunities for model evaluation continue to evolve. c) OFA funding from NOPP to support a community-based model has not yet materialized, but an opportunity may be announced soon. In the absence of significant funding from NOPP, we have proceeded to develop the model with internal funding. d) The initiation of the CEM project (Hanes; Santa Cruz) has provided CMG with more resources for modeling, instrument development, and measurements, and new regional project have emerged that provide opportunities for model application and evaluation. Our strategy for (a) prioritizing experimental work, (b) maximizing the impact/results of past and ongoing regional studies to meet both regional study and modeling objectives, (c) technical support for model evaluation, development, and applications, and (d) delivery of data, tools, and model evaluations is presented below. An overview of coastal modeling efforts in the USGS is being developed by Sherwood et al. (2004) as a work product in Task 1. Prioritization of Experimental Work Experimental work in this project is prioritized according to the following criteria: scientific need for experiment results to improve key model components; capabilities of USGS facilities and investigators; mutually beneficial scientific opportunities associated with USGS regional projects; and opportunities for leveraging USGS efforts by taking advantage of external funding opportunities, well-designed studies, special facilities, or unique and enthusiastic collaborators. The largest experimental efforts are associated with EuroSTRATAFORM (see Tasks 4 and 5), which meets most of these criteria. Field experiments associated with the South Carolina project (see Task 3) are assigned a high priority because they provide support to a regional project and are coordinated with the Coastal Evolution Modeling project. Prioritization of the other experimental work is anticipated in FY06 work plans are discussed in Task 3. Regional Studies In FY06, this project will provide significant direct support to the following regional projects: So. California (Palos Verdes), South Carolina, and Massachusetts Bay. Investment in the WL Delft Hydraulics coop provides indirect support to other projects, notably Willipa Bay, Puget Sound, and the CEM project. Technical Support We hope to slightly increase the number of scientists and technicians available to develop modeling tools, prepare model input, run models, and evaluate model output. The leadership of Hanes and Signell provides us with an appropriate level of senior scientists, but we hope to combine SIR OE and OFA funding (possibly from NOPP) to improve capabilities at the technical level, both in Woods Hole and Santa Cruz. We also need to continue to develop new instrumentation and tools for data processing, so continued funding of these activities is included in the budget. Delivery of Data, Tools, and Model Evaluations Delivery of data associated with model-related field programs or laboratory measurements will continue to appear as data reports or open-file reports. Analyses of these measurements and their evaluation in the context of modeling will be published in the scientific literature. Improvements in the community coastal sediment-transport model will be continued to be publicly released as part of the Regional Ocean Modeling System.

IMPACT/RESULTS:

This project is relevant to a wide range of USGS mandates. Numerical models are a primary tool for assessing impact on coastal populations of natural hazards, climate change, pollution, engineering structures, and environmental restoration. Numerical models are also our best hope for predicting change in the coastal environment, and are increasingly useful tools for coastal management. Finally, numerical models are quantitative, testable representations of our working hypotheses for coastal processes. Ideally, our general knowledge and understanding of coastal processes can be stored in a well-posed model like the NCST, and information and predictions for specific cases can be extracted from the NCST. In this way, data obtained in regional projects informs the model, and the model become better tools for use in regional studies. The impact of this project extends beyond the primary products that others will use, which include model code, model tools, scientific papers, and applications of the model. The broader impact is the ongoing and iterative improvement of our understanding of coastal processes, as formalized in the model. The model serves as a working, testable hypothesis that is continually modified and improved by USGS scientists and collaborators. Outcome Statements USGS research into coastal modeling has resulted in the following improvements to the widely used Regional Ocean Modeling System: 1) a suite of robust turbulence sub-models, 2) accurate and useful advection schemes for sediment, 3) improved float tracking, 4) improved representations of surface and bottom boundary-layers, 5) more generic and useable output formats that adhere to climate forecast conventions, and 6) sediment algorithms, including bedload transport, suspended sediment transport, stratigraphy, and morphologic evolution. USGS promotion of open-source software has improved the quantity and quality of publicly available models for coastal sediment transport. The NCST model has been used for regional projects in Mass Bay and South Carolina. The NCST model has been tested and improved using data from USGS and collaborators working on the Hudson River and the Adriatic Sea.

PUBLICATIONS:

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